Impact of Tillage System, Rotation and Fungicide Application on Seed Yield and Protein Content of Wheat and Field Pea

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Abstract

The impact of tillage system, increasing broadleaf crop rotation frequency and foliar fungicide use on diseases, seed yield and protein content of wheat and field pea were determined in the second cycle of three 4-year rotations at Melfort from 1998 to 2001. A 4-replicate split-split plot design was used with three tillage systems (zero tillage (ZT), minimum tillage (MT) and conventional tillage (CT)) as main-plots, three rotations (1. barley-canola-wheat-barley; 2. barley-pea-wheat-canola; and 3. canola-pea-flax-barley) as sub-plots and foliar fungicide treatments (treated or untreated) as sub-sub plots. Tillage system had little impact on diseases in either wheat or field pea. In the drought year of 2001, seed yield of wheat was greater under ZT or MT than under CT. The trend for field pea was similar in 2001. In other years there was no difference in yield for either crop among tillage systems. Protein content of wheat was often greater under ZT than under MT and/or CT, but tillage system did not have a consistent effect on protein content in field pea seed. Rotation was not a major factor in disease severity of either wheat or field pea. Rotation had an effect on seed yield of field pea only in 2001, but there was no effect on seed yield of wheat in any year. For wheat, protein content in seed was greater in 3 of the 4 years (1998, 1999 and 2001) when it followed field pea than when it was grown after canola. Rotation had little effect on protein content in seed of field pea. Foliar fungicide application had the greatest impact on disease control and seed yields, although benefits varied from year to year. Fungicides increased field pea yield by 32 and 16% in 1998 and 2000, respectively and wheat yield by 19, 13 and 9% in 1998, 1999 and 2000, respectively. There was no yield increase for either crop by application of foliar fungicide in the drought year of 2001. For wheat, protein content in seed decreased with fungicide application, but the effect was significant only in 1998. For field pea, protein content in seed decreased with fungicide application in 1998 and 2000, most likely due to a dilution effect from increased seed production. In summary, foliar fungicides had the greatest impact of the factors examined to reduce plant disease symptoms and increase seed yield of either crop, however the magnitude of the yield increase varied among crop years depending on environmental conditions. Most importantly, the study indicated that increasing the frequency of broadleafed crops in a rotation did not result in increased diseases or lower yield of field pea.

Introduction

Producers have been aggressively increasing the numbers of broadleaf crops in rotations and at the same time adopting reduced tillage practices. These practices are expected to increase economic returns, reduce costs, conserve soil moisture and increase soil health. However a number of concerns have been raised such as the possibility of greater crop disease problems, due to increased amounts of crop residue left on the soil surface and a greater probability of sclerotinia stem rot, due to increased cultivation of susceptible broadleaf crops. The objective of this study was to evaluate effects of various tillage systems on three 4-year rotations consisting of increasing numbers of broadleaf crops. The impact of foliar fungicides was also examined for each crop within each tillage and rotation treatment.

Materials and Methods

The experiment was located at Melfort on a Black Chernozemic silty clay loam soil from 1994 to 2001. The trial was a split-split plot design, with four replications and each phase of each rotation occurring every year. Main plots were tillage systems (conventional tillage (CT) – fall and spring tillage with harrow and packing of the seed bed; minimum tillage (MT) – spring tillage with harrow and packing of the seed bed; zero tillage (ZT) – no fall or pre-seeding tillage), conducted with a medium duty cultivator with 28 cm sweeps on 20 cm shank spacing. Sub-plots were rotations selected for increasing amounts of broadleaf crops (1. canola-wheat-barley-barley, 2. canola-barley-field pea-wheat, and 3. canola-field pea-flax-barley). Sub-sub-plots were fungicide treatments (treated or untreated). Quadris (azoxystrobin) was applied at early flower in field pea to control mycosphaerella blight [*Mycosphaerella*

pinodes and *Phoma medicaginis* var. *pinodella*]. Tilt (propiconazole) was applied at the flag leaf stage to control leaf spot diseases in wheat.

In this the second cycle of the study (1998 to 2001), the cultivars were AC Barrie wheat and Swing field pea in 1998 and 1999 and Highlight field pea in 2000 and 2001. Both crops were seeded with a 3.7 m pneumatic plot seeder and fertilizer was side-banded at seeding. All treatments had 100 kg/ha of 14-20-10-10. Nitrogen rates for wheat were calculated by using target N level (80 kg N/ha) minus soil residual N. Nitrogen fertilizer was not added to field pea plots.

Diseases were assessed on treated and untreated areas of each sub-plot. Wheat was rated for leaf spots (25 plants per plot) using a whole plant rating scale (0-11) and field pea was assessed on a 0-9 scale based on amount of stem and leaf area infected of 10 vines per plot.

Results and Discussion

Tillage systems: There were very few impacts on crop diseases in this study that could be attributed to the use of a particular tillage system (Tables 1 and 2). The most important impact of tillage system on crop yield occurred in 2001, where ZT yielded much more than CT (although significant only for wheat). In 2001, drought was the factor that had the greatest impact on crop yield. In 1998 and 2000, there was a trend of greater seed yield of wheat with CT than ZT. For wheat, protein content in seed decreased significantly in 1998 and tended to decrease in 1999 and 2000 with increased tillage. In 2001, ZT had the highest seed protein content, which was closely followed by CT, and MT had significantly lower protein than CT or ZT. For field pea, tillage system had no consistent effect on protein content in seed.

Rotations: Plant disease problems were not observed as a result of rotation (Tables 1 and 2). There was a concern that Rotation 3 (3 broadleaf crops and 1 cereal crop) would have a greater risk of sclerotinia stem rot in field pea, but this did not occur. Rotation had significant effect on seed yield of field pea only in the drought year of 2001, where field pea grown after canola yielded considerably less than field pea after barley. The effect of rotation on seed yield of wheat was not significant in any year, although in 2001 wheat grown after canola produced 239 kg/ha less seed yield than when it was grown after field pea. Total yield was usually greater in Rotations 2 and 3 than in Rotation 1. Protein content in seed was higher in 1998, 1999 and 2001 when wheat followed field pea than when it was grown after canola. There was little impact of crop rotation on protein content of field pea.

Fungicide use: The main diseases of wheat were septoria leaf blotch [*Stagonospora nodorum* and *Septoria tritici*] and spot blotch [*Cochliobolus sativus*]. Tilt decreased disease symptoms in every year and increased yield by 9-19% in 3 of 4 years (Table 1). Mycosphaerella blight of field pea was observed in all years of the test (Table 2). However, a yield increase due to application of Quadris fungicide was detected in only 2 years. A 32% yield increase was observed in 1998 and 16% in 2000. Protein content in wheat seed decreased significantly in 1998 and tended to decrease in 1999 and 2001 with fungicide application. For field pea, protein content in seed decreased significantly with fungicide application in 1998 and 2000. This was most likely due to a dilution effect of increased seed yields from the application of Quadris fungicide in those years.

Conclusions

Tillage system and rotation usually had little impact on crop diseases and seed yield under the 4-year rotations used in this study, with the exception of 2001 when zero tillage system had a definite benefit in terms of increased seed yield (particularly for wheat) under the drought conditions present in that year. There was a trend to lower protein content in wheat seed with increased tillage. Protein content in seed was higher in 3 years when wheat was grown after field pea than when it was grown after canola. Tillage and rotation had little impact on protein content of field pea. Fungicides had the most obvious impact on crop diseases and seed yield, although the benefit of fungicide application depended on the climatic conditions. Fungicides decreased protein content in seed in 1 year for wheat and in 2 years for field pea. The findings indicated that an increase in the number of broadleaf crops in rotation is possible without increasing disease severity or reducing seed yield of field pea.

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Table 1. Effect of Tilt fungicide, tillage system (ZT – zero tillage, MT – minimum tillage and CT – conventional tillage), and rotation (C – canola, W – wheat, B – barley, P – field pea , F – flax) on leaf spot disease rating (DR) and seed yield of AC Barrie wheat.

Treatment	1998			1999			2000			2001		
	DR (0-11)	Yield (kg/ha)	Protein (%)	DR (0-11)	Yield (kg/ha)	Protein (%)	DR (0-11)	Yield (kg/ha)	Protein (%)	DR (0-11)	Yield (kg/ha)	Protein (%)
Control	6.7	3265	14.8	8.3	2023	14.7	9.4	3282	13.3	3.7	1776	15.8
Fungicide	5.5	3873	14.1	5.4	2277	14.4	7.7	3575	13.4	3.1	1810	15.5
$Lsd_{(0.05)}$	0.3*[z]	173*	0.3**	0.6*	132*	0.3 [ns]	0.7*	87*	0.2 [ns]	0.3*	187 [ns]	0.3 [ns]
ZT	6.0	3504	14.7	6.7	2150	14.8	8.4	3378	13.6	3.3	2075	16.1
MT	6.0	3513	14.4	6.6	2138	14.4	8.7	3388	13.4	3.5	2015	15.0
CT	6.3	3690	14.3	7.1	2161	14.6	8.6	3519	13.2	3.4	1288	15.9
$Lsd_{(0.05)}$	0.5 [ns]	140*	0.3*	0.7 [ns]	125 [ns]	0.4 [ns]	0.7 [ns]	328 [ns]	0.4 [ns]	1.1 [ns]	702*	0.8*
B-C-W-B	6.0	3534	13.9	6.8	2087	14.3	8.5	3406	13.3	3.4	1912	15.0
B-P-W-C	6.1	3605	15.0	6.9	2213	14.9	8.7	3450	13.4	3.3	1673	16.3
$Lsd_{(0.05)}$	0.3 [ns]	186 [ns]	0.6**	0.6 [ns]	175 [ns]	0.4**	0.4 [ns]	184 [ns]	0.7 [ns]	0.6 [ns]	585 [ns]	0.6*

[z]*, **, *** and [ns] refer to significant at P<0.05, P<0.01, P<0.001 and not significant, respectively.

Table 2. Effect of Quadris fungicide, tillage system (ZT – zero tillage, MT – minimum tillage, CT – conventional tillage), and rotation (C – canola, W – wheat, B – barley, P – field pea , F – flax) on mycosphaerella blight disease rating (DR) and seed yield of Swing (1998-99) and Highlight (2000-01) field pea.

Treatment	1998			1999			2000			2001		
	DR (0-11)	Yield (kg/ha)	Protein (%)	DR (0-11)	Yield (kg/ha)	Protein (%)	DR (0-11)	Yield (kg/ha)	Protein %	DR (0-11)	Yield (kg/ha)	Protein (%)
Control	-	2462	26.8	3.1	2094	25.6	4.8	2003	24.8	3.8	2020	23.7
Fungicide	-	3237	26.0	3.0	2204	25.4	4.5	2317	23.9	3.8	1790	23.8
$Lsd_{(0.05)}$		239*	0.3***	0.1 ns	144 ns	0.2 ns	0.3 ns	110*	0.2***	0.2 ns	135*	0.2 ns
ZT	-	2827	26.8	3.1	2186	25.5	4.6	2288	24.5	3.8	2151	24.0
MT	-	3008	26.0	3.0	2160	25.4	4.8	2045	24.2	3.8	1919	23.6
CT	-	2713	26.5	3.1	2102	25.6	4.5	2148	24.4	3.8	1645	23.8
$Lsd_{(0.05)}$		607 ns	1.2 ns	0.2 ns	311 ns	0.1**	0.2*	407 ns	1.1 ns	0.3 ns	521 ns	0.4 ns
B-P-W-C	-	2729	26.6	3.0	2218	25.5a	4.6	2196	24.1	3.7	2119	23.7
C-P-F-B	-	2969	26.2	3.1	2074	25.6a	4.7	2125	24.6	3.9	1692	23.9
$Lsd_{(0.05)}$		259 ns	0.4*	0.1 ns	234 ns	0.3 ns	0.5 ns	297 ns	0.9 ns	0.2 ns	225*	0.2 ns

z*, **, *** and ns refer to significant at P<0.05, P<0.01, P<0.001 and not significant, respectively.